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Playing for Keeps: Developing Casino Games

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Gamasutra

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"Take a coin chute for the people to put their money in, and a cash box for the money to go into, and put something in between that will interest the people, and you've invented a slot machine." - Charlie Fey (1862-1944), inventor of the slot machine as we know it today.

Only unawareness, and some persistent Hollywood stereotypes prevents most people from recognizing the tremendous changes that are occurring in the gaming (gambling) machine industry. Long gone are the days when slot machines were placed in casinos only as amusements for the wives of high-rolling craps or blackjack players. Today's casino floors are brimming with high-tech machines that are capable of providing rich, immersive experiences, and the revenue they produce far exceeds that which flows across the green felt gambling tables. This article will explore the history and evolution of the slot machine industry, and provide some insight into the development processes used to create these games. Those from the PC and console game businesses may be surprised to see how similar the development of these devices is to their own profession. We will also delve into the special math considerations involved in creating a successful gaming machine, and take a look into the complex, ubiquitous regulatory structure that oversees most aspects of the industry.

Before we begin, let's debunk some common urban legends regarding slot machines. There is a popular misconception that a game can be made "looser" (made to pay back more) or "tighter" (made to pay back less) simply by turning a screw or knob inside the game cabinet. Others believe that the games are "fixed" to hit big jackpots on predetermined days, such as major holidays or grand openings. This simply isn't the case. The outcome of every handle pull on a modern gaming device is a completely random event (or at least as random as today's technology allows). As we shall see, it's possible to control the overall odds and payback rate on a machine, but not possible (and highly illegal) to control individual game outcomes. Regulators, casino owners, and game manufacturers go to great lengths to maintain the fairness of all games, both in fact and in perception.

Why? Because the importance of electronic gaming to the modern casino industry is enormous. Gaming devices (which include all types of electronic gambling devices, including reel-spinning slot machines, video slots, and electronic versions of live games such as poker, keno, and blackjack) account for nearly 75 percent of all casino revenues, and fill over 80



This game is an example of a "traditional" reel-spinning slot machine. This particular model has an overhead wheel and LED panel to display game messages and bonus information.

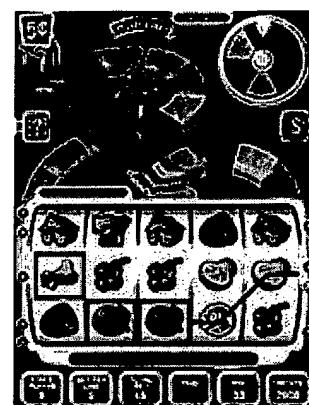
reels or blast pixels onto a video screen.

percent of the total casino floor space. It's estimated there are approximately 460,000 gaming devices in legal operation throughout North America and the annual replacement market alone runs around 70,000 units annually. Let's take a look at how the industry grew to what it is today.

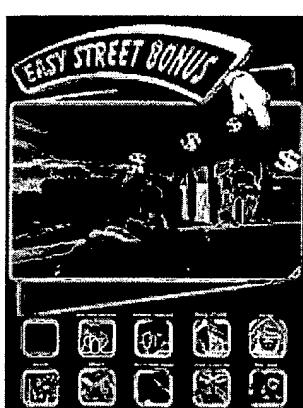
Bells and Cherries: A Brief History

Slot machines first appeared on San Francisco's Barbary Coast in the 1890s. California laws of that era prohibited gambling machines that paid jackpots in money, so the games were redesigned as "trade stimulators." For example, if a lucky player lined up matching symbols on the reels, the owner of the establishment would pay the winner ten cigars. The fruit symbols (cherries, plums, and so on) used on the reels of modern slot machines originated from this scheme, as these icons once represented payouts of fruit-flavored chewing gum. It's a safe bet to assume that a dollar or two was paid out instead of cigars or gum when the police weren't around.

The state of Nevada legalized casino gambling in 1931, thereby creating a legal American market for slot machines. Games of that era were completely mechanical, using complex collections of springs, wheels, and gears to drive the spinning reels. Mechanical games were the norm until the early 1960s, when Bally Manufacturing introduced Money Honey, the industry's first electromechanical slot machine. The game was a huge success. Computerized reel-spinning slot machines were introduced in 1981, and video-display games were introduced during this period as well. Today, virtually all legal gaming devices in the United States are microprocessor-based, whether they spin



The main reel screen from CDS's Easy Street slot game.



The second-level bonus screen from CDS's Easy Street video slot game.

the means to increase the entertainment value offered by their games drastically.

In the early 1990s, the convergence of two events had another profound impact on the industry. First, legalized casino gaming exploded beyond its historical boundaries of Nevada and Atlantic City. Many local and state governments were looking for ways to increase tax revenues, and gaming seemed like an easy way to fill the public coffers. Riverboat casinos were launched on the Mississippi River at a pace that would have made Mark Twain proud. At the same time, new federal rulings allowed for a tremendous expansion of gaming on Native American lands. (The world's largest casino, Foxwoods, is owned by the Pequot tribe in Ledyard, Conn.) The result of this surge in demand was the slot makers now had substantial amounts of cash to fuel further R&D efforts.

The PC gaming industry was experiencing a boom of a different sort during that era. "Multimedia" was the buzzword of the day, and the impact that the introduction of the CD-ROM had on the computer gaming world needs no repeating here. Forward-thinking slot manufacturers realized that a similar revolution could be carried over to their industry as well, providing

Technological Changes

Before this innovation could begin, some fundamental changes to the standard game architecture had to be made. Traditionally, gaming devices are ROM-based, with all game code, graphics, and sound residing in programmable, read-only memory modules (EPROMs). This architecture, which is still in wide use today, is rugged and has certain security advantages. The security aspect of burning all of the game control code into nonvolatile EPROMs is particularly important, given the highly regulated nature of the industry (I'll expand on this later), and the huge amounts of money that can be at stake. Nonetheless, this architecture has all of the inherent limitations that are associated with classic coin-op arcade games. Most EPROM-based system boards operate at very slow clock speeds, support only a limited amount of memory, and have basic graphics capabilities at best (typically 4-bit color).

Programming tools for these platforms are typically limited to simple DOS-prompt linkers and C compilers. As such, it is difficult to enhance the player experience significantly within the constraints of this environment. The challenge was to develop a new platform that could still provide the security and reliability of an EPROM-based game, and at the same time allow for vastly improved graphics, sound, and interaction.



Several "banks" of CDS *Easy Street* slot machines with accompanying signage.

The industry took several different approaches to this challenge. In 1997, the state of Nevada approved a new platform based on PC-style hardware (all gaming devices must pass regulatory muster before they can legally be offered for play). This device utilized a Pentium processor, a hard disk, and a full-color graphics subsystem to deliver content. All game code and media assets were encrypted and stored on the hard disk, which was jumpered to prevent unauthorized writing to the drive. While the games offered on this platform were traditional (slots, video poker, and video keno), the increased graphics capabilities, professional-quality animation, and high-caliber sound offered a considerably modernized playing experience. However, many gaming jurisdictions perceived problems with the security of this architecture, and further approvals were slow in coming.

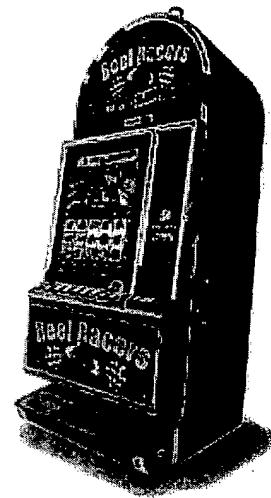
A more rounded approach was later developed by my employer, Casino Data Systems (CDS), which keeps all game control functions (the code which controls random number generation, win decoding, money handling, security, and accounting functions) in EPROM and utilizes a PC-based system for storage and execution of the multimedia functions only. With the platforms in place, titles could now be developed which took advantage of the increased capabilities.

Game Development and the Target Marketplace

In broad terms, the development of gambling games is not significantly different from the development cycle used in the PC, console, and coin-op games industries. A market segment is identified and targeted, a specification is defined, prototypes are produced, tested, and refined, and if all is successful the title is moved into full production. The unique aspects of game development in this industry involve special math considerations and meeting the regulatory requirements that address almost all aspects of a game. These regulations can have some unusual side effects on the day-to-day production work. Art, programming, and business have always been somewhat tentative bedfellows; adding government to the mix can really shake things up.

The overall demographics of the gaming market are not difficult to identify. The minimum legal gaming age in all jurisdictions is 21, and the baby-boomer and older demographics are the key targets for casinos, given their higher percentage of discretionary income. This tends to make the game designs more conservative than other mediums. Older adults are also typically less computer-literate than younger people, so games must be kept "comfortable" even for the customers who do not know how to program their VCRs. Furthermore, this design parameter also drives significantly less content than is typical for other forms of entertainment. Gaming devices would never have hundreds of levels or dozens of characters, for example.

Within these constraints, target marketplace segments can be identified in several ways. They can be categorized by the nature of the games (reel-spinning slots, video slots, video poker, and so on), by denomination (a game that accepts nickels is designed and targeted differently from a \$1 game, for example), or by the targeted player type. In general, the industry has perceived two categories of customers, the "tourist" and the "local." Games designed for the tourist market have traditionally been flashier, easier to understand and play, and higher-earning for the casino. The local player typically looks for games that have the highest payback percentage (often video poker), ignoring the bells and whistles of the tourist-style games. In the past, locals' games received little attention in areas such as game choreography, interactivity, and graphics and sound quality. However, the aforementioned technological breakthroughs, along with improvements in the game design process, have resulted in new titles that have broad appeal to players of all types, and the tourist/local distinctions are beginning to blur. (They have also resulted in significantly shorter replacement cycles. As with the PC gaming industry, the faster the technology advances, the faster it becomes outdated.)



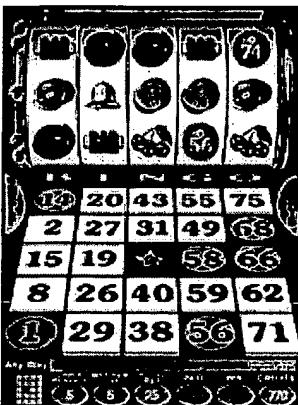
CDS's Reel Racers video slot machine. The hardware deployed in casino games must be robust enough to withstand 24/7 operation in less than ideal conditions.

Designing a Successful Gaming Experience

A successful game design satisfies the following objectives:

Initial attraction Why will this game be attractive to players when placed on a casino floor with thousands of other games? Some games lure players simply by offering a large jackpot, while others offer unique themes, recognizable brand names, or just an attractive overall package. These games are typically placed in banks of four to twelve machines and are offered for play 24/7, a rigorous environment to say the least.

Player appeal What are the game characteristics that will keep people playing once they have chosen this game? Again, certain models



CDS's Bandit Bingo game.

accomplish this by offering the promise of a huge jackpot, but players are increasingly opting for models that offer a higher level of overall entertainment value.

Completion What is the goal the player is striving for? This again can be simply a large top award, but the trend is to develop games with enhanced secondary features over and above the standard game play. Examples of these features include bonus games: different game levels which are reached by satisfying a specified objective in the primary game. Bonus games typically feature special animation, distinctive music, and most importantly, the opportunity for additional payouts.

Celebration What type of feedback does the game provide when the player wins a jackpot or achieved a game milestone? Casino gaming is typically a very social experience, and providing feedback to the player that he or she has accomplished something special is critical to a game's success.

Not surprisingly, these objectives aren't that different from those established for non-gambling games as well.

Also similar are the tools utilized for prototyping and development. After game and math concepts are established and storyboarded, prototypes are built using Macromedia Director or similar proprietary tools. Once a game is approved for production, code is typically developed in C or C++ (usually with Visual C++), although code destined to execute from EPROM may be written with legacy or custom tools. Artwork is developed using all of the usual suspects: 3D Studio Max, Lightwave, After Effects, and of course Photoshop. Custom graphics tools may be used to dither images to lower color depths or convert to proprietary file formats.



Chance from the Easy Street game shown here with a background scene.

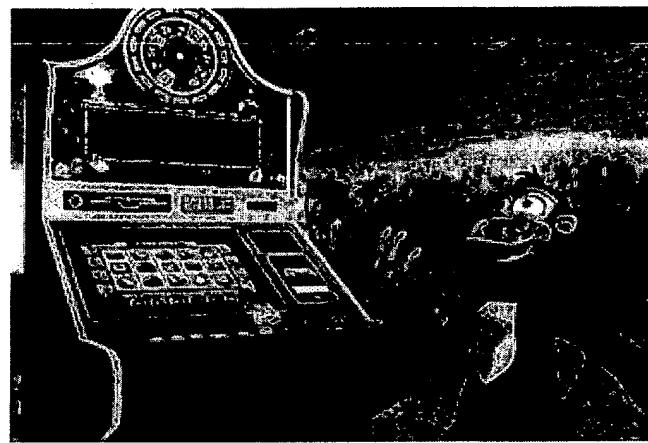
In an ideal world, the workflow of game development follows closely the procedures detailed in the article "Bringing Engineering Discipline to Game Development" (*Game Developer*, December 1998). But as we're all aware, factors such as market conditions, personnel changes, and simple deadlines can compress development cycles to something less than the theoretical ideal. Still, it's critical to respect the conventional alpha/beta/silver/gold release process in order to refine game attributes, squash bugs, and prepare the title for regulatory submission. Product development cycles can vary significantly; market opportunities have driven games from storyboard to shipping dock in as little as six months. More typical development cycles run 12 to 18 months.

The distribution channels for gaming devices can be particularly brutal. Unless a title is extremely strong, most casinos demand a trial period before they will commit to a purchase. During this period, which is typically a minimum of 30 days, casinos get to keep and operate the games at no cost to them. Once concluded, they then make the choice to keep or return the game. Often a buyer will request that the machine be converted to another title if they feel the installed one is not earning enough; these conversions are also typically done at no cost to the buyer. Then, should the casino decide to move ahead with the purchase, often a substantial discount is requested (the logic being that they are buying a used game at this point). Most game manufacturers distribute their games directly, although third-party distributors are often used for international markets.

Money for Nothing

Because these are gambling games, the game math is a critical factor in the success or failure of a title. This math determines, on a statistical basis, how big and how frequently the jackpots are hit.

A game that is perceived by players as offering neither high payouts nor any other type of entertainment value will quickly be shunned by the marketplace. The basic math considerations are a game's hit frequency (the statistical percentage of plays in which some type of payout is awarded), as well as the overall payback percentage (the percentage of money wagered by players that is returned to them via payouts). Most jurisdictions have established laws that require gaming devices to offer a minimum payback percentage of 75 percent, and it may be surprising to some that the great majority of modern games return at least 90 percent of the total monies wagered.



Outtake from the *Monkey Business* promotional movie.

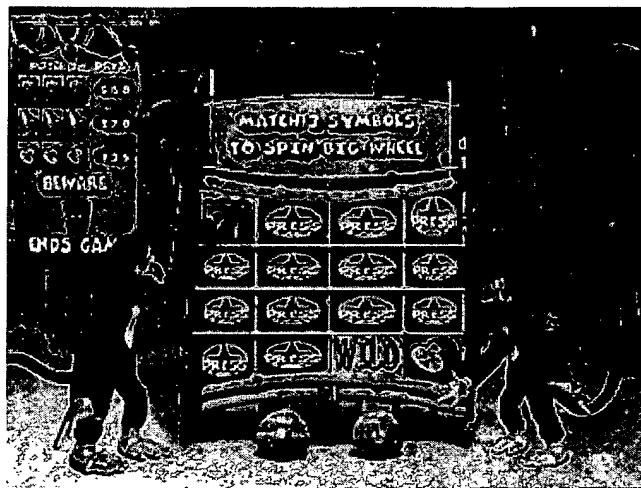
With some game types, the overall payback percentage is dependent to some extent on player skill. Games such as video poker and video blackjack, for example, require the player to make certain decisions during each hand of play (such as which cards to hold). The skill and strategies used can swing the payback percentage several points in either direction. This is an important factor in the design of video poker games in particular (generally regarded as the most popular "locals" game), as some models can offer up to (and sometimes even more than) 100 percent payback with the right strategy.

At the heart of the math engine (and indeed, the game itself), lies the random number generator, or RNG. A far cry from the simple random functions provided by most development environments, a gaming device's RNG consists of sophisticated algorithms designed to ensure that all outcomes are as random as is technologically possible. The best RNGs use algorithms that change the random seed constantly and unpredictably, as the ability to detect predictive patterns in a game is a classic cheating technique.

When a game is initiated, output from the RNG is funneled through the odds calculations. At this point, the game outcome is calculated and displayed (either by spinning reels or a video screen), and evaluated for potential winning combinations. Payouts are based on the amount wagered and the paytable, the schedule of awards for any given game outcome. Naturally, the longer the odds of hitting a certain combination, the higher the payout will be. It's important that the paytable be displayed and communicated clearly to the player, otherwise disputes are likely to result. Traditionally, paytables were printed on the backlit glass that is part of almost all game cabinets, however the increased popularity of video-based games has allowed developers to display more informative and interactive paytables on the video monitors. These paytables, along with general game help, are usually accessed through touchscreen buttons.

More Technology, and the Call for Professionals to Build It

In addition to the math engine, modern gaming devices have several additional subsystems critical to their success. I/O functions are very important, as the games must monitor all internal functions. Examples of these functions include coin and bill handling, button and/or touchscreen status, and integrity checks (door open, for example). Regulations mandate that games constantly monitor these functions and go into "tilt" mode should any abnormalities be detected. Games must be able to survive an unexpected shutdown gracefully with absolutely no loss of data, as very few casinos provide adequate uninterruptible power supply (UPS) systems on their floors. Additionally, a complete game history log must be kept in nonvolatile memory (typically on an EPROM chip) so that casino personnel and regulators can review the game's history should a customer dispute erupt.



**First-level bonus screen of
CDS's *Monkey Business* game.**

Networking capabilities are another important consideration in today's machines. The great majority of casinos today utilize slot monitoring systems, which are in effect large, real-time databases of machine information and player data. All games on the casino floor are networked to this database via proprietary, encrypted protocols. These systems have enabled the development of the popular slot clubs, wherein customers sign up to have their play monitored online. Once enrolled, players earn bonus points based upon their play. These points can then be redeemed for cash or merchandise. Casinos benefit from these systems not only by attracting player loyalty, but also by building a tremendous database of marketing information. They also use these systems to extract a great deal of accounting and security information from the gaming devices, and are required by law in many states.

Games may also offer progressive jackpots, which increase over time and are based on the amount wagered by players trying to win them. These jackpots are typically advertised on large overhead LED or plasma TV signage, and other proprietary, encrypted protocols (typically serial-based) have been developed to enable communication between the games and the displays. Games can be networked together to form a progressive link, where play from all games contributes towards one large jackpot pool. In recent years, these networks have grown to encompass machines spread throughout a state (and in some cases, several states), thereby enabling the posting of lottery-sized jackpots (with accompanying lottery-sized odds, of course).



As a result of the advancing technology and design methods, the gaming device business offers significant job opportunities for game programmers and artists. The skill sets necessary for these professions are virtually identical to those sought after in other types of game development, with the advantage to those who have a background in (or a penchant for) the mathematical areas. Nevada, the home of most major manufacturers, has never been known as a major hotbed of technological talent, so when the need to find staff arose, the industry turned toward (not surprisingly) Silicon Valley. Several major manufacturers (including mine) have established design studios in the Valley, where it's easier to attract world-class talent. Others have found offering relocation to Nevada attractive due to the significantly lower cost of living. Still others prefer simply to outsource their multimedia production to well-known California studios.

Popular Titles

CDS's Easy Street video slot machine (complete cabinet). The game, part of CDS's Bandit model series, utilizes a hybrid ROM/PC architecture to achieve high security while delivering engaging, immersive content.

Within the video classification, poker games remain popular, mainly because of their high payback rates. Growth potential for these games remains limited, however. The real boom is occurring in the video slot arena, where designers can implement myriad features unavailable on any mechanical-reel machine. The hot ticket today is "secondary bonusing," the addition of different game levels beyond the base reel game. Initially, these were implemented as simple second-level screens that appeared over the slot reels and allowed the player to make several game-show type choices (picking one of several doors, for example). The result of these choices is almost always a bonus payout. Current game choreography expands on this premise.



The main reel screen from the CDS Monkey Business game.

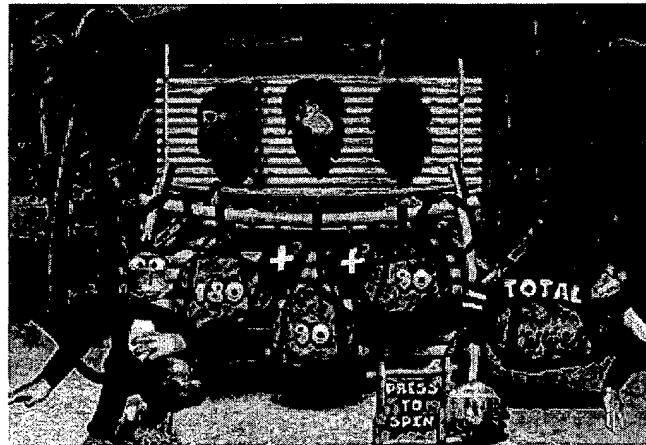
In CDS's *Bandit Bingo*, for example, players begin by choosing a bingo card that is placed on-screen below the slot reels. As players spin the reels, bingo ball symbols appear. Should a bingo

ball symbol match a number on the card, it bounces off the reels and daubs the bingo card. Once players have bingo, they are taken to a second screen where they choose one of five special bingo balls for a bonus payout. This game offers the opportunity to play two traditional casino games simultaneously (slots and bingo), and also provides for the bonus experience. *Easy Street*, another CDS title, offers a road-based board game as the initial bonus. Players earn bonus payouts for each successful turn on the board, and should they make it to the end they are taken to an additional bonus level. Here, an animation of the game's main character, Chance the Dog, plays in a window. As Chance drives his car down Easy Street, players use the touchscreen to select any of the buildings he passes for an additional bonus jackpot.

Recently, the industry has begun to look beyond its own borders for attractive content. This has resulted in a recent surge of games based on licensed brand names from outside the gaming industry. Titles have recently been released that are based on board games (*Monopoly*), television (*Wheel of Fortune*), and deceased entertainers (*Elvis*). Although this approach offers instant brand recognition, and has been very successful in several cases, the huge royalties involved make development of such games a risky proposition.

The Long Arm of the Law

Underneath all of the design and technology lies the basic fact that these machines are designed for gambling, with the classic elements of chance, risk, and reward. Gambling has always been a controversial topic in the United States, and the industry's rapid expansion in the early 1990s provided plenty of fuel for the ongoing debate. In 1997, Congress authorized the National Gaming Impact Study Commission, the purpose of which was to report on the economic, political, and social effects of the gaming industry.



**The second-level bonus round from
CDS's *Monkey Business* game.**

Because of the controversy, as well as the somewhat notorious origins of casino gaming (remember the movie *Casino*?), the industry is subject to intense governmental regulation on all levels. Businesses wishing to enter the industry must go through a vigorous background investigation by every state in which they intend to do business. These investigations, which delve into all aspects of an applicant's background, can cost well over \$100,000 per state with no guarantee that a license will eventually be issued. For this reason alone, the cost of entry into the industry is very high. All employees of a gaming company can be subject to personal background checks as well.

Beyond these corporate and personal licensing requirements, the games themselves are also subject to heavy regulation. Both hardware and software are subject to review, and the

laboratories that examine these games enforce strict rules on the randomness, payback percentage, security, and auditability of all games. Certain states (Nevada, New Jersey, Mississippi and Michigan) have established their own testing laboratories, while other states prefer to rely on the services of independent testing facilities such as Gaming Laboratories International. Hardware components are subject to environmental testing (electrostatic discharge resistance, line noise, and so on), and all software is reviewed at the source level. Approved programs are identified with a digital signature, and once approved, even a one-bit change to the code will render it noncompliant. The time required for these approvals varies wildly from jurisdiction to jurisdiction, but is typically never less than 30 days. Obviously, this added compliance time can have a major impact on shipping schedules.

The state of Nevada has recently added a new twist to the regulatory process by proposing rules that address game content itself. Specifically, these new regulations prohibit advertising on any gaming device, and further ban the use of any themes or artwork that may appeal to children. Obviously, the subjective nature of these proposed new regulations troubles many in the industry, and has already caused the withdrawal from consideration a game based on Comedy Central's *South Park* animated TV series.

No discussion of electronic gaming would be complete without touching on the rise of Internet gambling. Supporters of online wagering tout the convenience of simply logging on and betting. Despite this, true online betting carries enormous risks and has been shunned by the vast majority of the legitimate gaming industry. The primary reason is that the lack of any sort of comprehensive regulatory structure leaves Internet gambling ripe for fraud, abuse, and deception. There are no guarantees that any of these games are fair, or that players will actually be paid should they win and decide to collect. Not surprisingly, many of these sites are hosted from islands in the Caribbean, away from U.S. legal protections. Additionally, there is no easy way to guarantee that people gambling on the Internet are of legal age or capacity. As a result, Congress is currently considering a bill that would outlaw Internet gambling, and similar laws have already been enacted by several states. Until these problems can be resolved (if ever), Internet gambling will remain in that online netherworld currently inhabited by pornography and warez web sites.

This is not to say the Internet has been totally ignored by the legitimate gaming industry, however. Forward-thinking companies are developing marketing and other related programs which leverage the power of the medium without actually offering online wagering. For example, the previously mentioned slot monitoring databases have already begun to grow online hooks, and the prospects for similar systems are bright.

The Challenge of the Future

As the gaming device industry enters the 21st century, it faces many of the same challenges and opportunities present in the PC, console, and coin-op gaming worlds. Industry consolidation will continue, with the large, well-funded companies absorbing the smaller players. Advances in the technology employed will continue to shorten the life span of these games, although probably never to the extent that the PC and console markets must deal with. And fierce competition will continue to force the development of quality, interactive content, while never forgetting to offer players a good gamble. That's a safe bet.

Steve Boelhouwer is co-art director at Casino Data Systems, a leading designer and manufacturer of gaming devices. He has almost 15 years' experience in the casino gaming industry. Steve would gratefully like to acknowledge the assistance of fellow art director Kim Tempest and CDS founder and CEO Steve Weiss for their invaluable input into this article. Contact Steve at SBoelhouwer@csds.com.

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